United States Army School of Aviation Medicine
Fort Rucker, Alabama
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Student Handout

TITLE: Night Vision Orientation

FILE NUMBER: U3004500

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Night Vision Orientation
U3004500 / Version 1
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Prerequisite Lesson(s)

Lesson Number	Lesson Title
None	

Clearance Access

Security Level: Unclassified
Requirements: There are no clearance or access requirements for the lesson.

Foreign Disclosure Restrictions

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References

Number	Title	Date	Additional Information
0-7817-2898-3	Fundamental of Aerospace Medicine, 3rd Edition		
AR 40-501	Standards of Medical Fitness	30 Sep 2002	
AR 40-8	Temporary Flying Restrictions Due to Exogenous Factors	17 Aug 1976	
FM 3-04.301	Aeromedical Training for Flight Personnel	29 Sep 2000	
TC 1-204	Night Flight Techniques and Procedures	27 Dec 1988	

Student Study Assignments

Study SH and review reference material listed above.

Terminal Learning Objective

At the completion of this lesson, you [the student] will:

Action:	Manage the effects of visual limitations during night flight.
Conditions:	While performing as an aircrew member.
Standards:	In accordance with (IAW) FM 3-04.301, TC 1-204, FM 8-50, AR 40-501, and AR 40-8.

Safety Requirements

None.

Risk Assessment Level

Low

Environmental Considerations

None

A. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the functions of the rod cells during night flight.
CONDITIONS:	Given a list of functions
STANDARDS:	IAW FM 3-04.301 and TC 1-204 .

a. Rod cells allow us to identify the outlines of shapes and the silhouettes of objects. Rod cells are utilized mostly during time periods or conditions of low ambient lighting and darkness.

(1) The peripheral area of the retina is much more sensitive to light than the fovea (cone cells only) and parafovea regions (cone and rod cells). There are one hundred and twenty million rod cells located within the peripheral regions of the retina.

(2) Decreased visual acuity, color sense, and increased light sensitivity of the peripheral regions of the retina are directly related to the ratio of rod cells to neuron cells (10:1 up to 10,000:1).

(3) Use of your peripheral vision while scanning during unaided night flying will greatly assist you in maintaining a positive visual identification and location of flight hazards.

b. Retinal night blind spot.

(1) The night blind spot occurs due to the total absence of rod cells in the fovea and the lack of rod cell stimulation within the parafoveal regions.

(2) These regions are filled almost exclusively with cone cells, which are inactive due to the loss of ambient light. The non-effectiveness or inactivity of the cone cells causes or creates the night blind spot located within the center of the visual field encompassing an area of 5 to 10 degrees in width.

Example: To correct for this limitation, use of proper scanning techniques with ten degree circular overlap or off center viewing will assist the crewmember in identifying and maintaining visual reference of objects, possible hazards, and position of aircraft.

B. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the different types of vision when viewing during decreased ambient light conditions.
CONDITIONS:	Given a list of different types of vision
STANDARDS:	IAW FM 3-04.301 and TC 1-204.

a. Mesopic vision.

(1) During dawn and dusk lighting conditions and full moonlight time periods.

(2) Parafoveal region, a mixture of cones and rods becomes the primary source of vision.

(3) Visual acuity and color perception is limited due to the decrease of cones, and limited quantity of rods. Mesopic viewing period is considered the most dangerous period for viewing and depth perception.

b. Scotopic vision.

(1) Night vision (partial moon and star light lighting conditions).

(2) Use of peripheral vision (mostly rods).

(3) Acuity degraded to 20/200. Silhouette recognition degraded and loss of color perception. You can identify shades of black, gray, and white.

(4) Performance of off-center viewing and ten-degree circular overlap scanning techniques is necessary to compensate for the night blind spot

C. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the factors that affect dark adaptation.
CONDITIONS:	Given a list
STANDARDS:	IAW FM 3-04.301 and TC 1-204.

(1) Cones contain a chemical called iodopsin. Cone cells pick up certain colors depending on their pigmentation sensitivity. These colors are red, blue, yellow, or green.

(2) Rod cells are activated by a chemical known as rhodopsin (visual purple). Rhodopsin increases the rods effectiveness during dark viewing periods. On an average it takes 30 to 45 minutes to achieve full effectiveness for your rods to be dark adapted for your night vision.

b. The bleaching affect of the photoreceptor cells is another factor that affects dark adaptation.

(1) Bleaching of the cones and rods occurs when eyes are unprotected and exposed to direct bright light or solar glare.

(2) Cumulative unprotected exposure to bright light or solar glare may increase your dark adaptation time up to 3 to 5 hours, causing negative effects upon your night vision acuity.

(3) The duration of exposure of strobe light versus flare may have adverse affects to your night vision acuity and dark adaptation.

c. Poor nutrition and dietary habits are other contributing factor affecting dark adaptation.

(1) Vitamin A deficiency hinders production of rhodopsin, which is required for the effectiveness of the rods during dark viewing periods or conditions.

(2) Consuming a well balanced diet that includes such foods as milk, cheese, carrots, green leafy vegetables, and organ meats (liver, heart etc.), will provide sufficient amounts of Vitamin A that is required for the production of rhodopsin.

WARNING: Do not supplement Vitamin A in its pure form; it may have a toxic affect upon you physiologically. If supplementing for Vitamin A is necessary, a One a Day multivitamin is sufficient for the production of rhodopsin. Consult your Flight Surgeon before taking Vitamin A supplements.

D. ENABLING LEARNING OBJECTIVE

ACTION:	Identify limitations of night vision.
CONDITIONS:	Given a list of limitations
STANDARDS:	IAW FM 3-04.301 and TC 1-204.

a. Depth perception.

(1) Perception may be that you believe or assume that you are higher in altitude than you actually are (false interpretation or judgment of actual altitude related to poor depth perception).

(2) Use proper crew coordination to assist in determining your actual altitude.

(3) If mission permits use your search light or landing light. Utilizing these methods will greatly assist you in obtaining clarity in relation to your aircraft's position and altitude in regard to the ground or objects below it.

b. Visual acuity.

(1) Visual acuity during the photopic period is at best (20/20). While viewing during scotopic periods, visual acuity degrades to 20/200 or greater.

(2) Loss or degraded image sharpness and clarity.

Note: Performing preflight mission planning with a complete crew is essential when performing night flight operations. Identifying published hazards on the map in relation to your flight route, noting their location and altitudes will greatly assist in the safe completion of such flights.

When possible, perform day reconnaissance flights to prepare for night flight operations. Identify and note all unpublished obstacles and hazards in regards to their locations and altitudes. Disseminate this information with your crew and flight operations for updating of unit maps.

c. Night blind spot.

(1) The night blind spot increases in size with distance.

(2) Proper scanning techniques must be employed to avoid hazards.

d. Dark adaptation period.

(1) The use of red lens goggles while remaining in an artificially lighted area will assist in decreasing the average amounts of time necessary to properly dark adapt.

(2) Unprotected exposure to bright light or solar glare during day flights, night flights, and crew resting time periods adversely affects night vision acuity and dark adaptation sensitivity of the rod cells. Normally it takes 3 to 5 minutes to regain full dark adaptation from an unprotected exposure to bright light. The time that it takes to readapt may be increased due to poor night vision preparation, decreased levels of rhodopsin, and multiple exposures during flight.

(3) Blue wave length light can have adverse affects upon night vision acuity, dark adaptation, and creates the onset of night myopia (near sightedness) during flight. This may occur by having the console lighting intensity set to high. Operating console lighting and if applicable rear cargo area over head light (blue or white) at high levels of intensity during extended flight time will bleach out the rhodopsin. Set console lighting intensity high enough where the pilot can read the information provided by the instruments without having to stare in order to gain the information (maintain safety of flight). Crewmembers in the back of the aircraft will inform pilots up front prior to operating rear compartment lights. Crewmembers will use the lowest possible intensity level to perform task and not allow the light to bleach out the other crewmembers rhodopsin.

e. Loss of or degraded color vision.

(1) Due to the lack of cone cell stimulation, color perception will be degraded or lost. Obstacles may not be seen or identified as rapidly as they would be during the day.

(2) Color perception will be limited to shades of gray, black, and white. This can only intensify your visual limitations during night unaided flying.

(3) Rod cells are used primarily at night to identify the outline of obstacles (silhouette recognition) which will assist you in determining their shapes and sizes.

f. Night myopia occurs due to blue wavelengths of light prevailing in the visible spectrum. Because of this, slightly nearsighted (myopic) individuals will experience visual difficulty at night when using blue-green lighting.

(1) Aircrew members with perfect vision will find that image sharpness will decrease as pupil diameter increases. For individuals with mild refractive errors, these factors combine to make vision unacceptably blurred.

(2) These factors become important when aircrew members are relying on terrain features during night unaided flights. Special corrective lenses can be prescribed to correct for night myopia.

Note: The visual system is the most reliable of the senses, however, some illusions can result from a misinterpretation of what is seen. As visual information decreases, the probability of spatial disorientation increases. Reduced visual references may cause several visual illusions.

g. Visual Cues (binocular and monocular) are harder to distinguish when viewing under decreased ambient light conditions. This viewing condition causes aircrew members to stare at objects or terrain features longer in duration. The negativity of this is that misinterpretation of what is viewed is often the result due to the decrease ambient light condition.

Example: Proper crew coordination and communication combined with a detailed day reconnaissance flight and map reconnaissance prior to actual night unaided flight will greatly reduce the negativity when viewing under darkened conditions

(1) Binocular cues depend on the slightly different view each eye has of an object. Binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of both eyes. Distances are usually so great in the flight environment that these cues are of little value especially viewing under dark conditions. These cues operate on more of a subconscious level than monocular cues do. Study and training will not greatly improve them.

(2) Monocular cues are derived from experience and are subject to interpretation. Monocular cues can assist you in identifying possible hazards to include man made structures, associated terrain, and actual position of the ground in reference to your present altitude and position.

(a) Geometric perspective can be remembered by using the acronym LAV.

(1) Linear perspective.

(2) Apparent foreshortening appears elliptical (narrow).

(3) Vertical position in the field.

(b) Retinal image size can be remembered by using the acronym KITO.

(1) Known size of objects.

(2) Increasing or decreasing size of objects.

(3) Terrestrial association.

(4) Overlapping contours or interposition of objects.

(c) Aerial perspective is when distant information can be gained by the clarity of an object or by the shadow that is cast by an object.

(1) Fading colors or shades occurs when objects viewed through haze, smoke, or fog is seen less distinctly and appear to be at greater distance than they actually are. If atmospheric transmission of light is unrestricted, an object is seen more distinctly and appears to be closer than it actually is.

(2) Sharpness and clarity of details or texture is lost or is less apparent with distance.

(d) Motion parallax (one of the most important cues to depth perception) is the apparent, relative motion of stationary objects as viewed by a moving observer. Near objects appear to move past or opposite the landscape. Far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance the observer is from the object. Rapidly moving objects are judged to be near while slow moving objects are judged to be distant.

E. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the methods to protect visual acuity from night flight hazards and limitations.
CONDITIONS:	Given a list of methods
STANDARDS:	IAW FM 3-04.301 AND TC 1-204.

a. Lasers are utilized widespread throughout the United States armed services and foreign militaries. The use of lasers as a weapon system has and will continue to occur by our opposing forces. Most lasers that generate enough power (intensity) will not be seen by the naked eye. Even when flying under aided conditions laser, exposure is a possibility.

(1) Lasers injuries are primarily associated with your eyes, and can occur from a considerable distance. Distance is the best protection, but if that is not possible the use of laser specific protective goggles and visors B-LPS (Ballistic and Laser Protective Eyewear) will provide protection.

(2) During your pre-mission planning you should attempt to identify what the types of lasers, where, and when you may possibly be exposed to during your flight. Identifying the specific type of laser will assist you in obtaining the correct laser protective goggle or visors that are required prior to your flight.

(3) Unprotected laser exposure impairs night vision acuity.

b. Nerve agent hazards are always a possibility and can be present during night operations.

(1) The timely manner in which you identify the physiological effects of nerve agents during night operations may determine the success and survivability of your crew.

(a) When direct contact occurs, minute amounts may cause miosis, constriction of the pupils. Pupils will not dilate (enlarge) in low ambient light as they would normally. Chemical alarms may not detect presence of nerve agents.

(b) Exposure time required to cause miosis depends on the agent concentration and the cumulative effects of repeated exposure.

(c) Symptoms range from minimal to severe depending on agent's concentration and duration of exposure.

1) Severe miosis may persist for 48 hours or longer after onset of exposure.

2) Complete recovery may take up to 20 days or longer.

(2) There will be some loss of night vision among personnel exposed. Refer all exposed personnel to the flight surgeon immediately before performing flight duties or aircraft maintenance.

c. Exposure to bright light during night unaided flight. Sources of light can consist of but are not limited to:

(1) Aerial and ground flares, spot lights, vehicle headlights, search lights, and beacon lights.

(2) Protective measures consist of turning your head away from the source, covering or closing one eye, transfer of the controls if copilot is available and not experiencing the same negative effects, or change aircraft heading if mission permits.

d. Over all protective methods used to protect night unaided vision from flight hazards and limitations include:

(1) Lowering of clear visor.

(2) Adjust cockpit lighting to lowest readable level.

(3) Lower the intensity of your aircraft's interior and exterior lighting if mission permits.

(4) Close or cover one eye briefly when unexpectedly exposed to a bright light when flying night unaided.

NOTE: Each eye dark-adapts independently. By closing or covering one eye you will retain a large percentage of your night visual acuity of the covered eye or closed eye.

(5) Use supplemental oxygen if available when flying above 4,000 feet.

NOTE: The onset of hypoxia and its adverse affects upon your night vision may occur as low as 4,000 feet in altitude.

(6) If mission permits utilize search light or landing light.

(7) Use of B-LPS (laser specific protective visors and goggles).

(8) Gain distance from laser source and get out of the laser path.

(9) Avoidance of brightly lit areas.

(10) Use short ordinance burst (flash of bright light or tracer).

(11) Nutrition: consume a balanced diet (vitamin A supplement).

(12) Hydration: consume water; eyes need abundance of oxygen to function properly. Dehydration causes a decrease in fluid circulation, which reduces oxygen levels in blood stream. Dehydration can cause blurred vision and staring.

F. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the effects of the self-imposed stresses.
CONDITIONS:	Given a list of self-imposed stresses and their functions.
STANDARDS:	IAW FM 1-304.301, TC 1-204, and AR 40-8.

a. Drugs.

(1) Illness, degradation in motor skills, awareness level, and reaction time are all possible side effects related to drugs.

(2) Refer to AR 40-8 for restrictions for drug use while on flying status. Self-medicating is not authorized; consult Flight Surgeon for approval of drug use (medications).

b. Exhaustion.

(1) Poor physical condition and exercise, lack of rest, and irregular sleeping patterns or habits are all contributing factors leading to exhaustion.

(2) Common side effects related to exhaustion are altered concentration, awareness, attentiveness, increased drowsiness, and ineffective night vision viewing techniques (related to staring not scanning).

c. Alcohol.

(1) Long lasting physiological effects related to the consumption of alcohol.

(2) Detrimental effects related to the consumption of alcohol include poor or altered abilities upon judgment, decision-making, perception, reaction time, coordination, and scanning techniques (tendency to stare at objects).

(3) Histotoxic hypoxia is the saturation of tissue cells with alcohol or drugs causing interference with the use of oxygen (decreased tissue perfusion). The consumption of one ounce of alcohol places an individual at 2,000 feet physiologically.

NOTE: AR 40-8 states that crewmembers will not perform flight duties within 12 hours of consuming an alcoholic beverage and then until there are no residual effects remaining.

d. Tobacco smoking causes hypemic hypoxia, which is the greatest threat to night vision.

(1) Effects of tobacco (smoking of cigarettes) are decreased night vision viewing capability by an average of 20 percent at sea level and increased chance of becoming a possible hypoxia casualty when flying at higher altitudes such as for example instrument training or other flights at altitudes up to 10,000 feet.

(2) The physiologic effect at ground level is the same as flying at 5,000 feet.

(3) Hypemic or anemic hypoxia is caused by the reduction of the oxygen carrying capability of the blood (via the red blood cells- RBCs). Carbon monoxide binds with the hemoglobin, not allowing or severely decreasing the amount of oxygen allowed to bind with the hemoglobin.

WARNING: Carbon monoxide has an affinity for hemoglobin 200-300 times greater than oxygen. Smoking 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24-hour period will increase the carbon monoxide content of the blood 8 to 10 percent. Even more importantly, the smoker has lost approximately 20 percent of the night vision capability at sea level.

e. Hypoglycemia and nutritional deficiency.

(1) Effects of hypoglycemia and nutritional deficiency results in hunger pains, distractions, breakdown in habit patterns, and shortened attention span.

(2) Contributing factors leading to low blood sugar (hypoglycemia) and nutritional deficiency are skipping, missing, or postponing meals.

(3) Poor dieting can lead to Vitamin A deficiency, which hinders production of rhodopsin. Consumption of a balanced diet to produce the chemical rhodopsin should consist of the following foods: eggs, butter, cheese, liver, carrots, and most green leafy vegetables

G. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the proper night viewing (scanning) techniques.
CONDITIONS:	Given a list of proper viewing techniques
STANDARDS:	IAW FM 3-04.301 and TC 1-204

a. Scanning.

(1) Stop-turn-stop-turn motion scanning technique should be used. For each stop, an area approximately 30 degrees wide should be scanned. The viewing angle includes an area approximately 250 meters wide at a distance of 500 meters. The duration of each stop is based on the degree of detail that is required, but no stop should last longer than two to three seconds to prevent the rhodopsin from bleaching out the image.

(2) Ten degree circular overlap viewing should be utilized when moving from one viewing point to the next. Crewmembers should overlap the previous field of view by ten degrees.

b. Off-center viewing can be used to compensate for the night blind spot.

(1) You view an object by focusing ten degrees above, below, or to either side of the object you're viewing in order to maintain visual reference of the object so as not to bleach it out and lose sight of the object.

(2) Ten degree circular overlap and off-center viewing are used in combination as in one and the same when it comes to night unaided viewing.

H. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the physiological effects of night vision devices (NVDs).
CONDITIONS:	Given a list of physiological effects
STANDARDS:	IAW TC 1-204.

a. The immediate effects after viewing through NVDs to unaided viewing is decreased ability to perceive accurate depth perception, distance estimation, degree of contrast, discoloration of objects (chromatic), and the possibility of induced spatial disorientation.

b. Chromatic adaptation is a discoloration of objects viewed with the unaided eye after viewing through NVDs (ANVIS) for an extended period of time. This is a normal physiological response. It causes no discomfort and will disappear or subside within three to five minutes on the average. It will take on the average this amount of time to regain your dark adaptation and night vision acuity to the thirty to forty minute level-degree of effectiveness.

c. Spatial disorientation maybe induced by the following:

(1) Aircraft bank greater than 30 degrees.

(2) A scanning technique consisting of rapid head movements.

(3) Unfamiliar perception related to lack of NVG experience.